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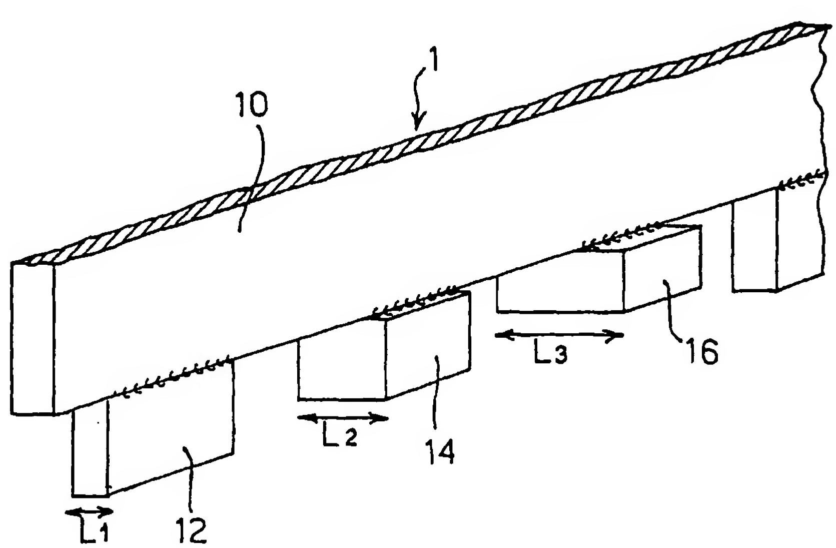
(54) Title: STONE CUTTING TOOL WITH DIAMOND SEGMENTS



(57) **Abstract:** A diamond tool (1), for cutting marble, granite or stone in general, comprises a metal core (10), for example a disk or a blade, and a plurality of diamond segments (12, 14, 16) applied by welding to the core itself, arranged in ordered and repeated sequences of three different segments each, these segments having, inside of each sequence, progressively decreasing heights and increasing cutting widths, with respect to a preferred cutting direction of the tool, at least one of the segments having a cutting width that is less than the width of the core (10).

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STONE CUTTING TOOL WITH DIAMOND SEGMENTS

DESCRIPTION

The present invention refers to a tool provided with segments, sectors or diamond plaques, used for cutting marble, granite, stone in general, conglomerate, cements and similar materials, and to the related cutting method.

In particular, the invention refers to a set of diamond segments, containing natural or artificial diamond particles or other very hard materials, applied to the external circumference of a disk or on a longitudinal side of a blade.

Disks and blades are generally used for different applications, because of their different uses. The comparison between diamond disks and blades highlights the substantially different use made of diamond plaques applied respectively to the external circumference of the disks or to a longitudinal side of the blades.

The differences are substantially in the cutting directionality, cutting speed and speed constancy.

The disk in fact always rotates in the same direction while the blades work with a reciprocating movement varying cyclically the cutting direction. This continuous change in the cutting direction makes it more difficult for the individual diamond to stay in the binder in which it is immersed. The bi-directional stress tends to more quickly undermine it from its seat, often before its useful life ends, shortening therefore the useful life of the tool.

The disk can rotate at a speed that is deemed optimal for cutting the material. Such speed is suggested to be about 20 m/s for cutting granites rich in quartz and hard stones, while it rises to 40 m/s and above for cutting calcareous and soft stones. In a gangsaw blade the reciprocating movement and the relevant masses involved limit the possible speed of the tool on the material at values that are less then a tenth than those possible in a disk.

The disk speed is constant, while the blade speed is of a sinusoidal shape that starts from

zero, accelerates up to the maximum speed at half of its stroke, for then returning to zero, and then it repeats itself in next movement along the opposite direction.

Notwithstanding the fact that disks and blades are used differently there are no substantial differences in the diamond segments used.

The most evident differences found in diamond tools are instead related with the hardness of the material to be cut: for marble and soft stones, in fact, synthetic diamond and blinders are used that are different from those used for quartz-rich granites and hard stones in general.

Although the studies and experiments about binders and artificial and natural diamonds respectively continue on used metallic alloys and on processes for coating the diamonds with adhesion-improving substances, currently, tools for marble are made of bronze-based alloys, while tools for granite are made of alloys in which cobalt prevails. Since for cobalt higher sintering temperatures are necessary, the used synthetic diamonds must have a better resistance to high temperatures.

Moreover, with the current technologies, while diamond disks are used in single or multi-disk machines for cutting either siliceous hard stones or calcareous soft stones, in mono- or multi-blade frame saws, the diamond segment blades are used only for cutting marbles, travertine, calcareous onyx and soft stones or inexpensive materials, sandstone and the like.

Cutting granite or hard stones by means of gangsaws is normally performed using loosen metallic grit as abrasive which, carried by water and mixed with additives, cuts the material because it has a substantially rectilinear reciprocating movement in contact with the material to be cut.

The attempts so far made for cutting granite and hard stones using blades containing artificial or natural diamond particles held together by various binders, copper, copper and cobalt and other metals, have still not given satisfactory results as regards the tool life and therefore cutting costs for square meter cut.

Special-purpose gangsaw have also been built, normally having vertical blades with respect to the block to be cut, using various arrangements, for example making the blades perform ellipsoidal

movements substantially on parallel strokes, in which the diamond segments are in contact with the block only during the active cycle. However, a gangsaw with diamond blades has never been built which is technically and economically efficient and that can replace the present frame machines for granite, using metallic grit, with analogous cutting costs.

A multi-blade gangsaw equipped with diamond segment blades suitable for cutting hard stones would have, among the others, obvious environmental advantages with respect to a metallic grit frame machine that produces pollutant residuals which are expensive and cumbersome to dispose of.

Lower durability and grater costs for cutting granite and hard stones using diamond disks, compared with wear and costs for cutting marble and soft stones, are certainly related with material hardness. Granites are at level seven or more in the Mohs hardness scale, a hardness which is much nearer to that of diamonds, which is ten, than marbles that are at level three. However, together with the hardness of the material to be cut, the problem of fast wear of tools has also to be taken into account, with the insufficient and too

difficult drainage of abraded material from cutting areas.

During disk cutting the material abraded by each segment in progression remains entrapped in the space that separates that segment from the following one, while all the abraded material which is generated interferes with the sides of the segment. The harder is the material to be cut, the sharper is the counter-abrasive effect on the diamond tool. Moreover, the open lateral spaces over the diamond segment, due to the differences in thickness between radial tools and disk core, are progressively reduced with the wearing out of diamond plaque thickness, progressively making the situation worse and accelerating the phenomenon. For this reason, the present trend is cutting granite by means of a plurality of very hollow passes, reducing thereby the number of disk teeth immersed in the material to a minimum. This provision however increases the total dead time of the cutting operation. When the disk fully cuts the material on a thickness of 2 or 3 cm, lower yields are acceptable.

As regards diamond blades, the phenomenon is more incisive and its negative effects are more

evident. While in a disk all segments come out from the material to be cut for the majority of its rotation, in a gangsaw only the segments on the two ends of the blades come out alternatively from the block purging the abraded material.

The most critical situation can be found at the centre of the block, where the material abraded by each stroke is re-dragged in the following cutting cycle and only long after that, it reaches one or the other end of the block. This helps to explain why, using a gangsaw, it is possible to cut materials having a hardness far from that of the diamond, and it is impossible to cut granites and other hard materials because of the excessive counter-abrasive effect of the abraded material on diamonds.

Figure 1 schematically shows a side view of a cutting tool or blade, realised according to the prior art, in contact with a stone block 3 to be cut and having, on the lower cutting edge, a plurality of diamond segments 2.

In Figure 2 the same blade is shown from the top, when cutting the stone block 3. The abraded material during the reciprocating movement of the

blade is accumulated in hatched areas 4 included between segments 2.

Because of the counter-abrasive effect on the segments, at present it is not possible and economically convenient to cut granite and hard materials using diamond segment gangsaw.

In a horizontal gangsaw, also the abraded material that rises laterally because of the reduced thickness of the blade relative to the segments, tends to fall, due to gravity, between the same segments and is dragged again frontward and backward until it is able with difficulty to find an exit at one of the block ends.

Similar problems to those created for the disk arise in vertical gangsaw having monodirectional diamond blades in the active stroke zone in contact with the block to be cut, worsened by the fact that, with respect to the disk, the contact area between tool and material is longer and the tool speed is reduced.

Some attempts have been made in order to facilitate the drainage of abraded materials from the cutting area, modifying the shape or the surfaces of the diamond segments or the tool core, disk or blade.

For example, Patent Application WO 95/22446 discloses a disk with diamond segments having an increased thickness in the contact area and decreasing towards the connection area with the disk core with a plurality of steps inclined with respect to the cutting direction.

In European Patent Application EP 0 287 847, the external surface of the diamond plaques is zig-zag shaped or has similar groove shapes in order to facilitate the drainage of abraded material.

In US Patent 4,550,708, some openings are placed between disk teeth and have the same length of the segment in order to collect the abraded material.

US Patent 4,490,039 provides some openings between diamond teeth that are extended towards the disk center, while the teeth have extended grooves for their whole height, providing channels to discharge the material.

The known solutions, however, do not allow substantially improving the drainage of abraded material in order to avoid the counter-abrasive effect on the tool by the previously-abraded material, an essential provision for lengthening

the tool life and accelerating the cutting process in particular when hard materials are cut.

A first object of the present invention is therefore substantially improving the ejection process of the abraded material, avoiding counter-abrasive effects and consequently lengthening the tool life.

A further object of the present invention is improving the tool cutting yield, without wasting abrasive material, and instead using the abrasive in the necessary amounts for the different working types and times. With the inventive arrangements, it is possible to realise a tool in which at least the width of the first cutting segment in every sequence of segments is less than the core width on which all segments are applied: this allows obtaining high savings in the total tool cost, in which there are a plurality of sequences of segments.

The above and other objects and advantages of the invention, as will appear from the following description, are obtained with a cutting tool and method as those respectively disclosed in Claims 1 and 17. Preferred embodiments and non-trivial

variations of the present invention are included in the dependent Claims.

The above-mentioned objects are in practice reached by a shape and a sequential arrangement of diamond segments having different profiles and compositions, that allow a more efficient washing system of the cutting grooves adapted to guarantee the expulsion of abraded material with a continuous flow of lubricating and washing water. The tool according to the invention can be advantageously used for cutting marble and calcareous stones, but also for cutting granite or other very hard stones.

The present invention will be better described by some preferred embodiments thereof, provided as a non-limiting example, with reference to the enclosed drawings, in which:

Figure 1 is a side view of a cutting tool with diamond segments according to prior art;

Figure 2 is a top view of the tool in Figure 1;

Figure 3 is a side view of a cutting tool with diamond segments according to the present invention;

Figure 4 is a front view of the tool in Fig. 3;

Figure 5 is a perspective view of the tool in Fig. 3;

Figure 6 is a side view of the tool in Fig. 3 in which the discharge flows of the abraded material are pointed out;

Figure 7 is a bottom view of the tool in Fig. 3 wherein the discharge flows of the abraded material are pointed out;

Figure 8 is a side view of a second embodiment of a cutting tool with diamond segments according to the present invention;

Figure 9 is a front view of the tool in Fig. 8;

Figure 10 is a side view of the tool in Fig. 8 wherein the discharge flows of the abraded material are pointed out;

Figure 11 is a bottom view of the tool in Fig. 9 wherein the discharge flows of the abraded material are pointed out;

Figure 12 is a side view of a disk-shaped cutting tool provided with diamond segments realised according to the present invention; and

Figure 13 is a perspective view of an alternative embodiment of a tool according to the present invention.

With reference to Figures 3 to 12, a cutting method according to the invention will now be described, which allows continuously cutting stone blocks or similar materials using a tool equipped with diamond segments.

The method provides the steps of:

realising a first groove whose width is L1 by means of a first segment 12 whose height is H1, the width L1 being less than the width of a core 10 on which the first segment 12 is applied;

enlarging the first groove realising a second groove, whose width L2 is greater than L1, by means of a second segment 14 whose height H2 is less than H1;

enlarging the second groove realising a third groove, whose width L3 is greater than L2, by means of a third segment 16 whose height H3 is less than H2.

This method allows the tool to remove the material progressively, each segment working on a reduced section and therefore on previously weakened material. Moreover, since the three segments realise grooves with different sections, a continuous water flow is always guaranteed,

laterally or below the segments themselves, which facilitates the drainage of abraded material.

With reference to Fig. 3, a cutting tool 1 is shown, in a schematic lateral view, that is realised according to the present invention, in particular a blade with diamond segments.

A metal core 10, which in this case is a linear metal band but could as well be a circular disk, has a lower edge 18 to which, by means of weld joints 20, diamond segments 12, 14, 16 are applied, that are made of a mixture of abrasive material and a binder whose characteristics and proportions depend on the material to be cut.

According to the invention, the diamond segments are arranged on the blade 1 according to repeated sequences of mutually different segments. Each sequence comprises three segments 12, 14, 16 having, according to a preferred cutting direction pointed out by arrow 22 in the figure, a height that is progressively decreasing and a cutting width that is progressively increasing, and in which at least one of the sectors has a cutting width that is less than the width of the core 10.

A first segment 12 has indeed a height H1 that is greater than the height H2 of the second segment

14, which in turn is higher than the third segment 16 having a height H3.

The first segment 12 is however narrower, cutting width L1, than the second segment 14, with cutting width L2, which in turn is narrower than the last segment 16, whose width is L3.

The segments of every repeated sequence on the blade 1 must therefore have the following characteristics: $H1 > H2 > H3$ and $L1 < L2 < L3$.

Each segment digs into the stone a groove having a profile different from that of adjacent segments, defining thereby a continuous and always open path for the abraded material, carried by the water flow used for its removal and for cooling the blade 1 when cutting.

In Fig. 4, wherein the tool in Fig. 3 can be seen from its front side, the different heights and widths of the three segments 12, 14, 16, that are present in each sequence, are evident.

Fig. 5 instead shows, in a perspective view, the tool 1 previously shown in Fig.s 3 and 4. In particular, a sequence of segments 12, 14 and 16 can be seen, fixed to core 10, having a progressively decreasing height H and a progressively increasing width L, in which the

width L1 of the first segment 12 is less than the width of core 10.

The new shape and group arrangement is useful for diamond disks and for gangsaw diamond blades, wherein it finds a better application in a mono-directional operation of the gangsaw in which tools are in contact with the material only during the active cycle.

The arrangement, however, is valid also in a bi-directional gangsaw, where there remains the problem of the easier undermining of the individual diamonds from the binder because of the reciprocating direction.

Similar sequences of segments having the same characteristics can be applied also to disk-shaped cores: in this case, however, the external surface of an individual cutting segment should follow the disk curvature with an increased radius with respect to the disk radius by a value equal to the height of the segment itself.

According to the invention, a sequence of cutting segments can also contain a number of segments that is different from three, for example only two segments, or four, five or even more segments.

Fig.s 6 and 7 instead show in detail, respectively in a lateral view and in a bottom view, the drainage flows that are formed when cutting and that always guarantee a complete removal of the abraded material by the water flow.

Each figure shows two sequences of three segments 12, 14 and 16 when cutting a stone block 3.

The spaces 22 comprised between individual segments are obviously open spaces for the passage of water and abraded material. The possible drainage flows next to each segment will now be described.

The first segment 12, whose lower portion 26 is immersed in the stone, laterally has two zones 24, horizontally hatched, for lateral drainage flow, since it moves in a larger channel dug by the second segment 14 and the third segment 16.

The second segment 14 has a portion 26 immersed in the stone, one lower drainage flow zone 28, vertically hatched, corresponding to the channel dug by the first segment, and two lateral drainage flow zones 24, corresponding to the larger channel dug by the third segment 16.

The third segment 16 is instead laterally immersed in the stone, while a drainage flow 28 is present below it that corresponds to the channels dug by segments 12 and 14 that precede it.

Moreover, segments 14 and 16 can possibly provide for a central front drainage, as shown in detail in Fig. 13, made of a longitudinal groove 60, 62, obtained in the lower part of each segment.

Due to all these passages and due to the empty spaces 22 being present between segments, a continuous channel is therefore guaranteed along the whole cutting area, which greatly facilitates the drainage function performed by cooling water and that completely avoids the counter-abrasion effect on the segments, since the abraded material can always and easily find a quick escape route.

The first, more projecting and thinner segment 12 can also have a thickness which is lower than that of the metal core 10 of the blade, while the last segment 16, the less projecting and thicker one of the series, defines the tool life.

The segments contained in each sequence can advantageously have mutually different lengths, in order to compensate for the different heights and widths and maintain their volume constant. In this

way, it is possible to compensate, for balancing the wear of various segments, the amount of abrasive material being present in each segment. Likewise, for similar requirements, the individual segments can also have different mixture characteristics C1, C2, C3 as regards mutually different abrasive materials and binding materials.

In particular, when the core is a disk, the mixture characteristics C1 of diamond powders of a first segment 12 vary between 30 and 35 carats/cm^3 and the mixture characteristics C2 of diamond powders of a second sector 14 vary between 25 and 28 carats/cm^3.

Instead, when the core is a blade, the mixture characteristics C1 of diamond powders of a first segment 12 vary between 25 and 28 carats/cm^3 and the mixture characteristics C2 of diamond powders of a second sector 14 vary between 22 and 25 carats/cm^3.

Normally, indeed, the cutting segments contain, according to the use for which they are aimed, particles of natural or artificial diamond, polycrystalline portions of tungsten carbide or other hard materials, together with various types of binding materials, for example copper alloys for

marble and soft stones or cobalt alloys for granite and hard stones. According to a preferred embodiment, the tool of the invention uses, for cutting granite, cobalt-based binding material and, for cutting marble, cobalt-based binding material with greater granulometry than that of the binding material for cutting granite

This particular arrangement on the core of diamond segments having different profiles has also the advantage of progressively fretting the material, each segment working on a reduced section and therefore on previously weakened material. This allows obtaining straighter cuts and a better drop speed between blade and stone block or vice versa.

Fig.s 8 and 9 show, laterally and frontally, a second embodiment of a cutting tool according to the present invention. Three cutting segments 32, 34 and 36, arranged in a sequence according to the above described characteristics of decreasing height and increasing width, are joined together and form an individual cutting element 30. The cutting element 30 can therefore be considered a single segment divided into three different portions, a first narrow and high portion 32, an intermediate portion 34 and a last, lower and

larger portion 36 than the previous ones.

This single segment 30, although having reduced drainage capabilities with respect to the above described embodiment, has the advantage of an easier assembling and/or alignment on the blade or disk core.

In order to facilitate the passage of the abraded material and the cooling water between adjacent portions 32, 34 and 34, 36, next to the discontinuities between the lateral surfaces, some vertical grooves 31 are present and perpendicular to the cutting direction of the tool.

Fig.s 10 and 11 instead show in detail, respectively in a lateral view and in a bottom view, the drainage flows that are formed when cutting with the tool shown in Fig.s 8 and 9.

In each figure three segments 30 are shown, separated by spaces 42, each segment being made of three different portions 32, 34 and 36, when cutting a stone block 3.

The spaces 42 comprised between adjacent segments are obviously open spaces for the passage of water and abraded material. Now, the possible drainage flows near the single portions of each segment will be described.

The first portion 32 has a lower portion 46 immersed in the stone and has laterally two zones 44, horizontally hatched in the figure, for the lateral drainage flow near the larger channels dug by the second portion 34 and the third portion 36.

The second portion 34 has a part 46 immersed in the stone, one lower drainage zone 48, vertically hatched, corresponding to the channel dug by the first portion 32, and two lateral drainage flow zones 44, corresponding to the larger channel dug by the third portion 36.

The third portion 36 instead is laterally immersed in the stone, while under it a drainage flow 48 is present, that corresponds to the channels dug by the portions preceding it.

The vertical grooves 31 facilitate the passage of the abraded material between adjacent portions of the same segment, creating a continuity among various drainage flows.

In Figure 12 another embodiment of a cutting tool using diamond segments according to the invention is shown. The segments are arranged, according to ordered sequences 50, on the circumference 11 of a disk-shaped metal core 10.

According to the invention, the diamond

segments are arranged on the disk according to repeated sequences of mutually different segments. Each sequence comprises three segments 52, 54 and 56 having, with respect to the preferred cutting direction pointed out in the figure by arrow 13, progressively decreasing height and progressively increasing cutting width.

As regards the diamond blades, it is evident that better results as regards tool wear are obtained on mono-directional gangsaws, in particular if the blade frame travels as moved away from the material to be cut next to end-of-stroke zones, wherein the speed is zero or close to zero, and during full backstrokes.

CLAIMS

1. Tool (1) for cutting granite, marble, stone or similar materials, comprising a metal core (10) to which a plurality of cutting segments (12, 14, 16) are applied, such segments (12, 14, 16) being made of a mixture of abrasive material and binder material, characterised in that said plurality of segments (12, 14, 16) comprise repeated sequences of two or more different segments, said segments having, inside of each sequence, progressively decreasing heights and progressively increasing cutting widths, with respect to a cutting direction of the tool, at least one of said segments having a cutting width that is less than a width of said core (10).
2. Tool (1) according to claim 1, characterised in that each sequence comprises at least three segments (12, 14, 16) having different heigths and cutting widths, applied to the core (10) spaced with each other, a width (L1) of a first sector (12) being less than the width of said core (10).
3. Tool (1) according to claim 1, characterised in that the segments contained into each sequence